Africa has most markedly increased its output, and in 1893 became the third producing portion of the world, the output being almost entirely in South Africa. While in 1891 Africa produced 23,687 kilograms = $15.-742,400, this had increased, in 1893, to 44,096 kilograms = $29,305,800, and it is probable this output will be greatly increased in the near future.

Of the remaining large gold-producing countries the output for 1893 is estimated to be as follows:

United States	54,100 kilograms	= $35,955,000
Australia	53,698 "	= 35,688,600
Russia	39,805 "	= 26,454,400

It is thus apparent that Africa has surpassed Russia.

With the greatly increased output of gold, the fields known to be rich but still undeveloped (South Africa, Australia and South America), and with the downward tendency of silver, it seems impossible that bi-metallism can exist for any length of time in the near future, even by the consent of all the nations of the globe. Gold may be made the circulating medium, or silver may be; but with the continual disparity in value between the two metals, which is not constant but varying daily, the two can only coëxist in subsidiary coinage, where they are mere tokens.

The fact is frequently lost sight of that gold and silver are only articles of merchandise like wheat, cotton or iron, and intrinsically are of less value than any of the three latter. A coin only means that the country whose stamp it bears guarantees it to be of a certain weight and to contain a certain percentage of gold or silver. Common agreement has made these articles of merchandise the means of paying balances, as a matter of convenience.

The Significance of the Jugal Arch.

By Daniel Denison Slade.

(*Read before the American Philosophical Society, March 15, 1895.*)

It is difficult to explain why that portion of the mammalian cranium which presents so prominent and striking a feature, even to the most careless observer, as does the jugal or zygomatic arch, should not have been considered worthy of more extended scientific notice than it has received. Cuvier, in his admirable treatise, *Anatomie Comparée,* seems to have been the only writer, familiar to us, who has comprised the anatomy and physiology of this region in any lengthy description.

While the present paper does not pretend to have, by any means, exhausted the subject, it claims to have brought together for the first time, under the light of modern science, a concise statement of the chief modifications which the arch undergoes in the various orders of the Mammalia.

This osseous bridge connecting the lateral regions of the cranium with those of the face is often composed of three bones, the malar or jugal in the centre, flanked on either side by the zygomatic process of the squamosal and by the malar process of the maxilla. Again, it may be reduced to two, the process of the squamosal and the jugal, or the process of the squamosal and the postorbital process of the frontal. The number of bones present depends upon the advanced or receding position occupied by the orbit, also upon the position held by the articulation of the mandible in relation to the orbital cavity, whether this be above, below, or on a level with the latter. Although the arch in certain cases is imperfect, it can rarely be said to be entirely absent.

The strength of the jugal arch, the most important factor in its existence, depends upon its line of direction, whether this be straight or curved, and upon the amount and manner of this curvature; upon the number, size, extent of surface, and mode of union of its component bones. These, in their turn, are correlated with the articulation of the lower jaw, and with the amount of surface presented by the ascending ramus; with the neighboring fossæ, crests and processes; with the dental series, and necessarily with the muscles concerned in mastication, varied as these are in their action.

The jugal arch, as it exists in the Carnivora, offers an instructive example of the various points to be considered in its morphology. In the tiger, for example, the arch, composed of three bones—the squamosal, malar and maxilla—presents an extraordinary horizontal curvature, thereby vastly increasing its expanse, giving great width to the temporal muscle, which taking its origin from the largely expanded surface of the parietal, and from the occipital-sagittal crest, passes forwards and downwards, to be inserted into the high, wide, oblique, coronoid process of the mandible. This increase in length of the arch, due to the great horizontal curvature, is also seconded by the advanced position of the orbit upon the skull, and by its height above the level of the articulation of the mandible.

The vertical curvature of the arch, with the convexity above and concavity below, denotes increased power of resistance to the strain produced by the muscular fibres of the masseter, which, springing from the under side of the arch, are carried obliquely backwards and downwards to be inserted into the deeply grooved ascending ramus. The action of the pterygoids, which is similar to that of the masseter, is also relatively powerful. The fibres rising from the pterygoid fossæ and plates are inserted into the inside of the angular portion of the lower jaw, and into the neck of the condyle. The suture by which the processes of the squamosal and jugal are joined, extends very obliquely through a greater portion of the arch; this obliquity imparting much strength to the bony structure, and thereby enabling it to resist the upward pressure.

The convex surface of the transverse condyle of the mandible, received into the deeply grooved glenoid cavity, forms the hinge-like articulation fitted for the vertical action of the jaw, and which is necessary for the prehension, tearing and division of the flesh by means of the characteristic teeth.

In the Edentata, on the other hand, the cranium of the great ant-eater exhibits a jugal arch which is the extreme opposite of that which has been thus partially described. Here, it is very incomplete, consisting of a short styliform process given off by a very rudimentary jugal, and of an extremely small tuberous zygomatic process from the squamosal, no union being formed between the two. There is no postorbital process of the frontal, and no separation between the orbital and temporal fossæ. Under these circumstances, the muscular development concerned in the preparation of the food is very feeble, correlated as it is with the entire absence of teeth and any necessity for mastication.

Between these two extreme modifications, there are many intermediate forms of this arch, as will become evident as we study them in the different orders of the Mammalia.

In the PRIMATES the arch is composed of two bones, the squamosal and malar, which are joined by a serrated suture which inclines downwards and backwards ; the amount of inclination being modified in the various groups of this order. The strength and curvature of the arch also widely vary, as does also the extent to which the various crests and ridges for muscular attachment are developed. In man, the arch is generally slender, slightly curved in its horizontal axis, and presents a very moderate convexity upwards in its vertical curvature. Owing to the slight horizontal curvature outwards, the temporal fossa is relatively shallow, consequently allowing but little development of the temporal muscle. This condition, however, is subject to modifications in the various races of man. The maximum breadth of the cranium is at the jugal arches, and it is at these points that craniologists now take the bizygomatic diameter of the face.

Humphrey, in his *Human Skeleton*, in speaking of this arch, says: "The upper surface of its root forms a smooth channel for play of the temporal muscle. In the negro the greater width of this channel throws out the zygoma into stronger relief, and added to the flatness of the squamosal portion, affords more space for the temporal muscle." This general statement is not confirmed by any cranial measurements, neither does Mr. Humphrey state what he means by a negro. Probably he intended, as in common parlance, to designate the African, although this designation is ambiguous, as it is well known that the crania of the different tribes of Africa differ very essentially in their general formation, as well as in their special cranial measurements.

Although the cephalic measurements of Broca, Topinard, and others allow a slight increase in the horizontal curvature of the arch in certain instances, which signify a greater development of the temporal muscle, as well as a more extended surface for the attachment of the masseter, yet, as Topinard remarks, in speaking of the bizygomatic diameter, "This measurement by itself often presents difficulties, purely accidental and local, and entirely apart from the general type. Thus, in every race, cases occur in which the zygomatic process of the squamosal, instead of joining directly with the malar, bends outwards and then resumes the general characteristic direction of the arch, whether this be straight or gently curved. The greatest width under the circumstances falls upon the summit of the bend, which causes the measurement to be unduly augmented."

As a result of the measurements taken upon the crania of the Africans in the collection of the Peabody Museum, and of the Harvard medical school, there was a slight increase in the bizygomatic breadth over those of other mixed European skulls. But no dependence should be put in such measurements, for although in one collection the crania were classified in general as African, nothing was known of their history, and still less of those with which they were compared.

Tables given by Topinard, Flower, and others, of the bizygomatic breadth compared with the total length of the face, apparently do not support the statement of Mr. Humphrey. A more satisfactory method of ascertaining the truth of the point in question would be to obtain by measurement the actual width of the groove in the upper surface of the posterior root of the zygoma, of the African skull and compare this with that of other races. This can be properly effected by taking first the bizygomatic breadth and then the bisquamosal at the most prominent point on the line of suture between the squamosal and alisphenoid ; the difference between the measurements would give the breadth of groove.

Cuvier reminds us that the size of the temporal fossa and its muscle have close relation with the age of the animal. In the young, the brain and its case are developed, but the jaws are small, and the forces which move them are wanting in energy. But with age these last are developed, while the intellectual powers constantly diminish. In civilized man, the equilibrium is maintained between the growth of the brain-case, the intellectual powers and the masticatory organs. Can any relation, however remote, be traced between the developed masticatory powers of the uncivilized negro, and the flattened squamosal of his brain case as described by Mr. Humphrey ?

The Anthropomorpha have strong jugal arches, longer than in man, and presenting marked horizontal and vertical curvatures. Although, strictly speaking, it is composed of only two bones--the zygomatic process of the squamosal and the jugal, this last rests upon a process of the maxilla so much developed, that in many cases it might be rightfully considered as entering into the formation of the arch. The suture which joins the squamosal and jugal is long and serrated, its great inclination downwards and backwards vastly increasing the strength of the parts as also the power of resistance.

In the gorilla, the arch is relatively broader and more developed than in the other higher apes. The process of the squamosal presents a sudden vertical convexity upon its upper border, at a point corresponding to the junction of the anterior transverse root, the remaining portion of the arch being nearly of the same width. The breadth of the channel for the play of the temporal muscle is proportionally large. The entire structure of the arch, especially in its horizontal-vertical curvatures, exhibits enormous strength. In the adult male all the cranial ridges attain their maximum size, thus presenting a largely increased surface for the origin of the temporal muscle, while the relative greater breadth of the ascending ramus of the mandible and the increased width of the pterygoid fossæ are correlated with a corresponding development of the masseter and pterygoid. The long and massive canines have reference to the powerful action of the last named muscles, while their use has a sexual relation. The glenoid cavity is transversely broader than in man, and more shallow, its anterior boundary, formed by the anterior root of the zygoma, being scarcely developed, thus allowing greater freedom for the antero-posterior movement of the articulation of the mandible.

In comparing the skull of the male gorilla with that of man, we shall find that the arch of the former is not only vastly stronger, but the bones present a different form and proportions. The squamosal is as long and vertically as wide as the malar portion of the arch, while its upper border rises into an angular form, constituting a very marked convexity, no trace of which is to be seen in man. In the latter the jugal portion of the arch decreases in depth after leaving the body of the bone, whereas in the gorilla it continues of the same depth and is relatively longer.

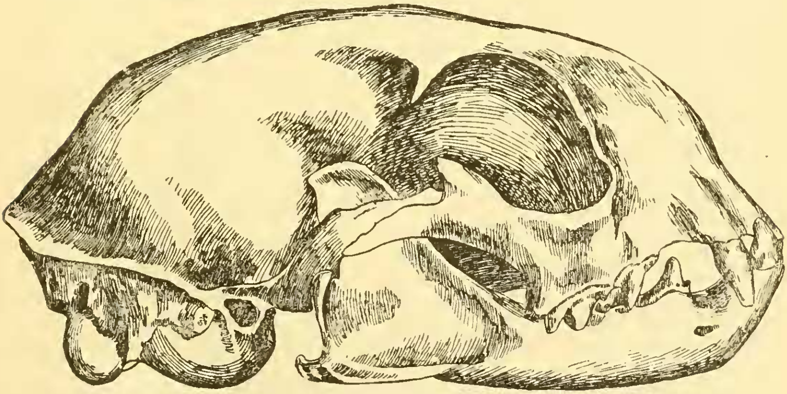
In the orang, the horizontal curvature of the arch is greatly produced, and strongly developed at the portion corresponding to the malar-squamosal suture. Its inferior border is flattened and thickened. The vertical curvature, however, is not so great, while the channel for the temporal muscle is relatively wider than it is in the gorilla. The crests and ridges of the cranium, especially in the male, express the great energy of this muscle, although the general outline of the arch is far less massive than in the latter ape.

The jugal arch of the chimpanzee presents much resemblance to that of man, being narrow, and with slight curvature, either horizontal or vertical. The malar is anteriorly flatter, and its orbital process is longer and narrower at its base. The extent of surface for the development of the temporal muscle is greater than in man, and the width of the channel relatively increased.

The slight modifications observed in the arch of the gibbons, exhibit a distinct tendency to those shown in the lower types of the Simiadæ. In the old-world monkeys, the arch takes on a sigmoidal curvature, thus presenting upon its superior border, a slight convexity behind and a corresponding concavity anteriorly. The extent of this curvature varies in the different groups. In the new-world monkeys, the postglenoid process of the squamosal is largely increased, while the remarkable extent of the ascending portion of the ramus, both vertical and antero-posterior, has reference in the howlers to the great development of the vocal organs, rather than to any unusual energy of the masticatory muscles.

In the Lemuroidea, the family of the common lemurs have an arch which in most cases is nearly straight, narrow, long, and distinguished by a malar-squamosal suture, which is almost horizontal in direction, the amount of the overlapping of the jugal by the lengthened process of the squamosal being exceptional, while in some cases the jugal is partially underlapped by a process of the maxillary.

As regards the Carnivora, the general characteristics presented by the arch and the adjacent regions have already been considered, when taking that of the tiger as a typical illustration of their morphology. The order of the Carnivora is divided into two suborders, the true or fissiped and the pinniped (the latter being organized mainly for an aquatic life). The true Carnivora may be classified under three sections—Æluroidea, Arctoidea and Cynoidea. The arch in the families comprehended under the first of these sections presents no modifications specially different from those offered by the Felidæ, unless we may except the Hyænidæ, in which the jugal arch is extremely wide and strong and the horizontal curvature very great. The postorbital of both frontal and jugal are largely developed, approximating each other, while the sagittal crest is high, giving large attachment to the very powerful muscle of the temporal. The ascending rami of the mandible present the corresponding extent of surface for muscular attachments. In the section Arctoidea, the family Ursidæ present an arch which is longer, and of which the horizontal curvature is greater than that of the Felidæ, while the jugal-squamosal suture is more oblique, and the entire bridge much less developed. In the Mustelidæ, the upward vertical curvature is large, but the entire arch is relatively slender.



In the Cynoidea, the strength and curves of the arch occupy a position midway between those of the other sections, being more developed than those of the Arctoidea, but exhibiting less strength than those of the Æluroidea.

The suborder Pinnipedia is easily separated into three families—the Otaridæ, the Trichecidæ and the Phocidæ. The first of these bear genetic relationship to the Ursidæ in many of the cranial characters. The arch is composed, as in the Fissipedia, of three bones. Of these, the jugal presents a wide backward progressing process, which divides into a short upper and a long lower one, receiving and supporting the extended process of the squamosal, as in a mortise.

The postorbital processes are well developed. A more or less distinctly marked sagittal crest exists with an extended surface for muscular attachment. The coronoid surface of the ascending ramus is wide, but not produced above the level of the arch.

In the Trichecidæ, of which Trichecus is the single genus, the maxilla enters largely into the formation of the arch, the jugal is shorter and broader than it is in the other families, and nearly quadrangular, sending up a prolonged postorbital process from its superior border, while posteriorly its inferior border underlies the process of the squamosal. The condylar surface of the mandible points backwards, while those of the rounded coronoids are scarcely lifted above the dental series.

In the Phocidæ, the composition of the arch does not differ essentially from that of the Otaridæ, although it is relatively much weaker. There are no postorbital processes, and the sagittal crest is less distinctly marked. The angle of the mandible is not inflected.

The Chiroptera are divisible into the suborders Magachiroptera and Microchiroptera. The family Pteropodidæ includes all the characters of the first of these suborders. In Pteropus, the arch is long and relatively slender, and composed of three bones, of which the jugal is splint-like, adhering to the outer and under surface of both the squamosal and maxilla, which meet above it and form the span.

The postorbitals of the frontal and jugal not unfrequently meet, and thus complete the bony orbit. There are strongly developed crests, both occipital and sagittal. The coronoid surface of the mandible is fitted for large muscular attachments, being high, broad and recurved. The angle is flattened and rounded, presenting an extended surface. Of the six families into which the suborder Microchiroptera is divided, the Vespertilionidæ may be taken as the typical representatives. The arch is slender and complete throughout the entire group, except in some of the Phylostomidæ, in whom it is entirely wanting.

When present, the horizontal curvature is large, and the vertical also considerable, the convexity being upwards. In its conformation, it is similar to that of the Pteropodidæ. The orbit is incomplete, the temporal fossæ are relatively large. The parietal crest is but slightly developed. The mandible is stout and high at the symphysis. The ascending ramus is compressed, and bears a coronoid process which is strongly indented for muscular attachment. Immediately below the condyle, is a backward projecting process. The dental series in this suborder resembles that of the Insectivora, the molars being cuspid. Adopting the classification of the highest authorities, and notably that of Dr. Dobson, the Insectivora may be divided into two suborders, the Dermoptera and the Insectivora Vera. Accepting the above classification, the Insectivora, so far as concerns the jugal arch, may be brought into three groups :

1. Those in which the arch is complete and well developed, comprising the Tupaidæ, Macroscelidæ, Rhynchocyonidæ, Galeopithecidæ.

2. Those in which the arch is complete but more or less feebly developed, comprising the Erinaceidæ, Talpidæ, Chrysochloridæ.

3. Those in which the arch is partially or wholly deficient, comprising the Centetidæ, Potamogalidæ, Solenodontidæ, Soricidæ.

The Tupaia may be taken as a typical form of the first group. The jugal arch is well developed, a postorbital process from the frontal meeting a corresponding one from the malar, thus forming a complete bony orbital ring. The malar has a large longitudinal oval vacuity, which, although unique in this case, when taken with similar vacuities in the palate of this genus, as also in some of the other Insectivora, points unmistakably to the Marsupialia.

The horizontal curvature of the arch is sufficient to counteract any inherent weakness due to the vertical curvature with its convexity downwards. The temporal fossa is moderately extended, while the coronoid surface of the mandible presents a large backward projecting surface, rising high above the transversely produced condyle.

In the second group, where the arch, although complete, is for the most part weak, the cranium presents marked modifications. In Erinaceus and Gymnura the arch is formed mostly by the processes of the squamosal and maxilla which join, while the malar is very small and occupies in a splint-like form the outer and under sides of the centre of the arch. There are no traces of any postorbital processes. The temporal fossa is deep and extended, while additional surface is afforded for the temporal muscle by the prominence of the sagittal and occipital crests. The ascending ramus of the mandible, with its broad, concave, coronoid surface, and the development of the pterygoid fossæ, denote increased masticatory powers, in spite of the apparent weakness of the buttress.

In the Talpidæ, certainly in all of the truly fossorial of the family, the jugal arch is slender, and exhibits no distinct malar bone, no occipital or sagittal crests, and no postorbital processes.

The mandible is long, and the vertical portion presents a moderately extended coronoid surface with a small transverse condyle. The infra-orbital foramen is of great size, being a very slender osseous arch which serves for the transmission of the large infraorbital branch of the trifacial, affording the necessary supply of sensory nerves to the muzzle.

In the Chrysochloridæ, which in the general shape of the skull present modifications different from all other Insectivora, the jugal arch is in some species so expanded vertically, that, as Dr. Dobson remarks, "their upper margins rise above the level of the cranium, giving additional origin to the large temporal muscles." There is no postorbital process given off either by the frontal or zygomatic arch. As regards the mandible, the coronoid process is little elevated, and in some species is nearly level with the transversely extended condyle.

In the third group the arch is incomplete, and in one instance, at least, may be described as entirely absent. In the Centetidæ, the skull is long and narrow, and marked by largely developed occipital and sagittal crests which serve as attachments for muscles of temporal origin. The zygomatic processes of the maxilla and squamosal are very short and rudimentary, while the malar is entirely absent. The temporal fossæ are very large, and the skull retains nearly the same width at their anterior and posterior regions. There is not a trace of a postorbital process. The infraorbital foramen is circular and capacious. There are no pterygoid fossæ. The coronoid process of the mandible is largely developed, its inner surface being concave, and its outer surface flattened. The condyle is small and circular, while the glenoid surface is transversely concave.

The other families of this group, with the exception of the Soricidæ, agree with the Centetidæ in the modifications of the skull that have been described. In the Soricidæ, the cranium is broadest just behind the glenoid surfaces. There is no jugal arch and no trace of a postorbital process. Frequently there is present a strongly marked lamboidal ridge as well as a sagittal crest. There is no pterygoid fossa, but very large vacuities exist on each side of the basis cranii. The mandible resembles that of the Talpidæ, although the horizontal ramus is shorter, while the ascending one "presents a very large and singularly deep excavation upon its internal surface quite characteristic of the genus." The articular surface of the condyle looks backwards instead of upwards. The angle of the jaw is elongated and thin. The infraorbital is large and bounded posteriorly by an osseous bar.

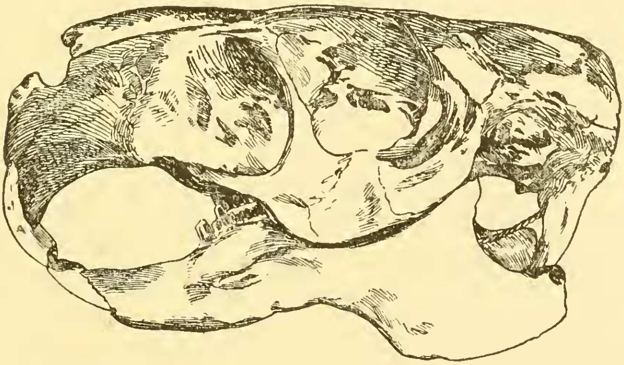
The jugal arch in the Rodentia is always present, and is generally complete, although it exhibits many modifications in its composition. Three bones form the arch, which is straight or slightly curved horizontally, while it almost invariably presents a curvature downwards. The position of the jugal therein serves as a determining character in grouping the various families of the order.

The temporal fossa is often small, showing feeble energy in the action of the temporal muscle. On the contrary, the pterygoid plates and fossæ are often largely increased in relation to the enlarged development of the muscular insertions. In close connection with these conditions, the coronoid process of the mandible is small and even rudimentary, while the parts about the angle are largely expanded. The condyle is little elevated and presents, with few exceptions, an antero-posterior articulating surface. Postorbital processes of the frontals exist in a few of the families, but in no case is there a corresponding process from the arch. The orbit is never separated from the temporal fossa.

In many of the rodents there is present a more or less extensive dilatation of the infraorbital foramen, through which passes, in addition to the nerve, that portion of the masseter muscle which has its insertion upon the maxilla. This extends around the back of the jugal process of the maxilla in a pulley-like manner to an insertion just below the socket of the mandibular præmolar, and thus coöperates with the temporal in moving the mandible in a vertical direction. This attachment of a head of the masseter is peculiar to the order, and explains the use of the vacuity in the maxilla which oftentimes is of vast relative proportions.

All existing rodents fall into two groups, the Simplicidentata and the Duplicidentata. The first embraces the Sciuromorpha, Hystricomorpha, Myomorpha, and the second, the Lagomorpha.

In the Sciuromorpha, the jugal forms the greater part of the arch, extending forward to the lachrymal and posteriorly to the glenoid cavity, of which it forms the outer wall, and is not supported below by a continuation backwards of the process of the maxilla. In the more typical forms there is no enlargement of the infraorbital opening, while the postorbital processes of the frontals are characteristic of the family Sciuridæ. The external pterygoid plate is entirely wanting and there is no fossa.



The arch in the Myomorpha is for the most part slender, and the jugal, which does not extend far forward, is supported by the continuation below of the maxillary process. The zygomatic process of the squamosal is short. No postorbital process of frontal exists. The infraorbital opening varies. In the family Muridæ, especially in the typical forms, this opening is perpendicular, wide above and narrow below, while the lower root of the zygomatic process of the maxilla is flattened into a thin perpendicular plate. Very much the same condition exists in the Myoxidæ, while in the Dipodidæ, the foramen is as large as the orbit, is rounded, and has a separate canal for the nerve. The malar ascends to the lachrymal in a flattened plate. In close connection with these conditions the coronoid process of the mandible is small and rudimentary, while the parts around the angle of the ramus are much developed.

In the Hystricomorpha, the arch is stout. The jugal is not supported by the continuation of the maxillary process, and generally does not advance far forward. The infraorbital vacuity is large and is either triangular or oval. The coronary process and the condyle are but slightly elevated above the dental series.

In the Chinchillidæ, the jugal extends forward to the lachrymal. In the Dasyproctidæ, Cælogenys is characterized by the extraordinary development of the jugal arch, which presents an enormous vertical curvature, two-thirds of the anterior portion of which, constituting the maxilla, is hollowed out into a cavity which communicates with the mouth. The nerve passes through a separate canal, adjacent to the infraorbital opening.

The jugal arch in the suborder Duplicidentata is well developed.

In the family Leporidæ, there are large wing-like postorbital processes, while the jugal, but feebly supported by the maxillary process, continues posteriorly to aid in the formation of the outer side of the glenoid articular surface, passing beneath the process of the squamosal.

The Lagomyidæ have no postorbital processes, and the posterior angle of the jugal is carried backward nearly to the auditory meatus. The infraorbital opening in the Duplicidentata is of the usual size. The angle of the jaw is rounded, and the coronoid process much produced upwards.

The Ungulata may at the present time be divided into the Ungulata vera, including the two suborders, Perissodactyla and Artiodactyla, and the Ungulata polydactyla, which comprises the two suborders, Hyracoidea and Proboscidea.

In its morphology, the jugal arch of the Ungulata presents various modifications. With few exceptions, two bones alone compose it, the squamosal and jugal, which are connected by a suture, the general direction of which is horizontal. Both the horizontal and vertical curvatures of the arch present considerable variations, as does also its relation to the neighboring parts.

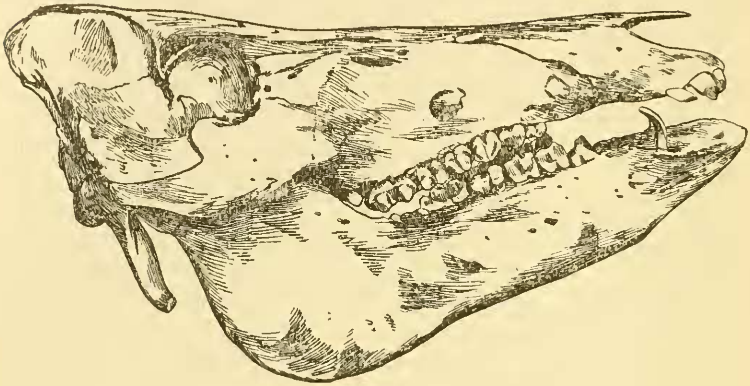
In the Perissodactyla, the family Equidæ exhibits an arch, which, although relatively slender, is quite exceptional in its arrangement. The large and lengthened process of the squamosal not only joins the greatly developed postorbital process of the frontal, but passing beyond, forms a portion of the inferior and posterior boundary of the orbit. The malar spreading largely upon the cheek, sends back a nearly horizontal process to join the under surface of the squamosal process above described, while the orbit is entirely surrounded by a conspicuous ring of bone, thereby clearly determining the bounds between it and the temporal fossa, which last is remarkably small. This fossa is bounded above and posteriorly by more or less well-developed crests and ridges. The pterygoids are slender and delicate, without the presence of any fossa. The glenoid surface is much extended transversely, concave from side to side, and bounded posteriorly by a prominent postglenoid process. The angle of the jaw is much expanded. The condyle is well elevated above the molar series, while the coronoid process is long, narrow and slightly recurved.

In the Rhinoceridæ and Tapiridæ, the arch is strongly developed, and composed of the squamosal and jugal processes, which are joined at about its centre by an oblique suture from above downwards, backwards and upwards. In the Tapiridæ, the arch is long, owing to the advanced position of the orbit. There is a small postorbital process, largest in the tapir, but the orbital and temporal fossæ are continuous. The surface for the temporal muscle is extensive. The glenoid fossa presents a transverse convex surface to articulate with the corresponding one of the mandible, which is not much elevated above the dental series. The coronoid process is slender and recurved, while the angle is broad, compressed, somewhat rounded and incurved.

In the Artiodactyla, the arch is slender and is composed of the process from the jugal, which passes backwards beneath the corresponding forward projecting process of the squamosal, the juncture being by a suture nearly horizontal in direction, and longest in the Cervidæ. The jugal sends up a postorbital process to meet the corresponding descending one of the frontal, the suture which unites them being about midway. The bony orbit is thus complete, while the jugal is forked posteriorly. The temporal region is relatively small. The horizontal curvature of the arch is very slight. The glenoid surface is extensive and slightly convex with a well-developed postglenoid process. The pterygoids present a large surface and are situated nearer the middle line than is the case in the Perissodactyla. The condyle is broad and flat, and the coronoid process is long, compressed, and slightly recurved. The angle is rounded and much expanded.

The Tylopoda alone among the Ruminantia have large surfaces with crests and ridges for the increased development of the temporal muscle. The horizontal curvature of the arch is greater than in the true ruminants, consequently the temporal fossa is wider and deeper—all in correlation with the powerful canine teeth. The forked articulation between the molar and squamosal is also more strongly marked.

Among the non-Ruminantia, the family Suidæ exhibit an arch in which the process of the jugal underlying the squamosal extends back to the glenoid fossa—the two bones being connected by a suture, which is vertical anteriorly for the depth of half the bone, and then horizontal. The postorbital process does not meet the frontal, in fact all traces of this are lost in Sus scrofa, but in the peccary and Barbaroussa it is quite prominent. The arch is short owing to the position of the orbit, and both vertical and horizontal curvatures are considerable. The narrow, transverse condylar surface of the mandible, and the small coronoid process with its rounded surface, are but slightly raised above the level of the alveolar surface. The pterygoid surface is extensive and the fossa deep.



In the Hippopotamidæ, the arch is broad and strong. Its superior border presents a marked sigmoid curvature, and the convexity which is always posterior, is in this case much shorter in proportion. The temporal fossæ, as also the surfaces for the muscular insertions, are extensive. The pterygoid surface is not so large as in the Suidæ. The glenoid fossa is slightly concave, but not bounded externally by a continuation of the jugal. The condyles of the mandible are nearly on a level with the molars, and the coronoid process is small and recurved. The angle is greatly modified for muscular attachment.

In the Hyracoidea, the arch is composed of three bones, of which the jugal is the most important. Resting anteriorly upon the maxilla, the jugal sends backwards a process to form the external boundary of the glenoid fossa. It also sends upwards a postorbital process to meet a corresponding one from the parietal alone or from the parietal and frontal combined, thus completing the bony orbit. Both horizontal and vertical curvatures are slight. The surface for the temporal muscle is largely developed while the pterygoid fossæ are well marked. The ascending ramus of the mandible is high, and the angle is rounded and projects very much behind the condyle, which last is wide transversely, and rounded on its external border. The coronoid process is small, slightly recurved, and not on a level with the condylar surface.

In the Proboscidea, the arch is straight, slender, and composed of three bones. The maxilla forms the interior portion, while the jugal supported upon the process of the maxilla, meets that of the squamosal in the middle of the arch, and is continued under this as far as the posterior root. This modification is unlike that of any other ungulate. There is a small postorbital process from the frontal. The temporal surface is extensive, and that of the pterygoid considerable. The ascending ramus of the mandible is high, and the condyle small and round. The coronoid process is compressed, and but little elevated above the molar series, while the angle is thickened and rounded posteriorly.

The jugal arch in the order of the Cetacea presents some singular modifications. In the Delphinoidea, the squamosal, frontal and jugal enter into its composition. The squamosal sends forward a large, bulky process which nearly meets the descending postorbital process of the frontal. The jugal is an irregular flat bone, covered by the maxilla, and sends back from its anterior and internal border a long and very slender process, curved slightly downwards, to articulate with the short obtuse process of the squamosal, thereby forming the lower boundary of the orbit. So far as the relations of the squamosal and frontal are concerned, the portion of the arch thus formed is a counterpart of that of the horse: although the union of the two bones is much more complete in the latter animal. The jugal in the horse is relatively a much larger bone, and sends back a well-developed process which underlies that of the squamosal, with which it is joined by a nearly horizontal suture, thus forming a strong suborbital bony wall. The delicate character of the suborbital process of the jugal, and its union with the squamosal in the Delphinoidea, render it difficult at first sight to determine its relation to the arch, and yet when compared with that of the horse, its homological character cannot be disputed.

In the Balænoidea, much the same conditions are presented, except that the suborbital process of the jugal is both stronger and more curved. The small capacity of the temporal region, as well as the limited extent of the arch in the Cetacea, are correlated with the modifications presented by the mandible, in which the condylar surface is small, and looks directly backwards. There is no ascending ramus, and the coronoid process is quite rudimentary—all of which conditions are in direct relation to the nature of the food, and absence of the masticatory movements.

In the Sirenia, the arch is greatly developed, being composed of the squamosal and the jugal. The former of these is much thickened and presents upon its external face a smooth, convex surface. In the Manatus, this process of the squamosal rests loosely upon the process of the malar, which, underlying it, extends back as far as the glenoid, having first formed a rim which is both suborbital and postorbital, besides sending a broad plate downwards and backwards, thereby greatly increasing the vertical breadth. The orbital fossa is separated almost completely from the temporal by a bony partition. The surface for the muscular attachments, both of the temporal and masseter, are extensive, while the pterygoid plates and groove are relatively enlarged. The vertical curvature of the arch is great, but the horizontal is inconsiderable. The ascending ramus of the mandible is broad, compressed, with rounded angle and surmounted by an obliquely placed, small convex condyle, much raised above the molar series. The coronary surface is broad, directed forwards, and but slightly elevated above the condyle.

In the Dugong, the arch is much less massive. There is no postorbital process from the jugal, and consequently no separation of the orbital and temporal fossæ by a bony orbit. The coronoid process of mandible looks backward.

Although the horizontal curvature of the arch is very slight in both genera of the Sirenia, the temporal fossæ are deepened and extended, conditions due to the walls of the cranium being compressed in a lateral direction, which materially increases the extent of surface for muscular attachment and development.

In the order Edentata, the jugal arch also offers unusual modifications. In the Myrmecophagidæ, it is very incomplete, being composed of the proximal end of the jugal, articulating with the narrow projecting process of the maxilla, and a very rudimentary fragment of the squamosal. These separate portions, however, do not meet, in fact they are widely separated. There is no boundary between the orbital and temporal fossæ, the latter being comparatively shallow. The glenoid fossa is a slight cavity running antero-posteriorly, and well adapted to the pointed, backward projecting condyles of the mandible, whose long straight horizontal rami present neither coronoid process nor angle. In Cycloturus, the mandible is somewhat arched, and presents a well-marked angular process, as well as a coronoid surface slightly recurved.

In the Bradypodidæ, containing the two forms, Bradypus and Cholœpus, the arch is imperfect, consisting of the jugal, which is narrow at its articulation with the lachrymal and maxilla, but which widening out into a broad compressed plate, terminates posteriorly in two processes, the upper pointing backwards and upwards, while the lower looks downwards and backwards. The straight process of the squamosal, although fairly developed, fails to meet either of those of the jugal. There is a postorbital process of the frontal, which is best marked in Cholœpus. The glenoid is shallow and narrow from side to side. The mandible, widest in Cholœpus, develops a rounded convex condylar surface, well raised up from the dental series, while the coronoid surface is large and recurved. The rounded angular process projects backwards to a considerable extent. The symphysis in both forms is solidified, while in Cholœpus it projects forwards into a spout-like process. The temporal surface for muscular attachment is large, as also are the pterygoid plates.

In the Dasypodidæ, the arch is complete, and in its formation the jugal largely enters. This bone extends from the lachrymal and frontal to the process of the squamosal, the anterior third of which it underlies. There is no postorbital process of the frontal. The glenoid presents a broad, slightly convex, transverse surface. The pterygoids are small. The mandible has a high ascending ramus, the condyle is transverse and above the alveoli, while the coronoid surface is large and the angle broad and projecting.

In the Manidæ, the arch is incomplete, owing to the absence of the malar, which if present would occupy almost the exact centre of the arch, the length of the squamosal process and that of the maxilla being nearly equal on either side. The temporal and orbital fossæ form one depression in the side of the skull. The rami of the mandible are slender and straight and without teeth, angle, or coronoid process. The condyle is not raised above the level of the remainder of the ramus.

In the Orycteropidæ, the arch is complete, and the horizontal curvature is very slight. The postorbital process is well-developed. The mandible rises high posteriorly, with a coronoid slightly recurved, and with an ascending pointed process on the angular edge below the condyle.

In the Marsupialia, the jugal arch is always complete, and composed of the jugal, resting on the maxilla and squamosal, the first extending from the lachrymal anteriorly to the glenoid fossa posteriorly, of which it forms the external wall. The process of the squamosal passes above the jugal, being united to it by an almost horizontal suture. The horizontal and vertical curvatures of the arch are considerable, and the space for both temporal and masseter muscular insertions is extensive. The various ridges and crests are large, especially in the Dasyuridæ and Didelphidæ. The postorbital of the frontal is present as a rule, although in most forms inconsiderably developed. The ascending ramus of the mandible is less elevated than in several of the orders of the Mammalia. The condyle is but little raised above the molar series. The masseteric fossa is extremely projected at its lower external border, and the mandible, with one exception, has an inverted border to the angle.

In the Monetremata, the Echidnidæ possess an arch in which the squamosal is compressed, and sends forward a slender straight process to join the corresponding slight shaft-like process of the jugal. The horizontal curvature is extremely small.

In the Ornithorynchidæ, the arch is made up of the malar resting upon a process of the maxilla, which, passing straight backwards, unites with the squamosal process that rises far back on the sides of the cranium. While the mandible of the Echidna has but the rudiments of the parts which usually enter into its formation, that of the Ornithorynchus is more fully developed in relation to the attachment of the horny teeth.

In studying the significance of the jugal arch according as this portion of the mammalian cranium has been presented to us in the preceding pages, while there are modifications in certain groups which are somewhat difficult of explanation, we shall find that the general laws which govern its morphology may be satisfactorily determined. These laws, concisely speaking, are, that the development of the arch, as shown by the number of the bones, by the degree and the number of the curvatures, by its relation to the orbit and articulation of the mandible, as well as to other neighboring parts, and by the amount of surface presented for muscular insertion, all depend upon the energy and character of the masticatory muscles. That these in turn depend upon, and are closely correlated with the habits and environment of the animal.

The above laws are very clearly exhibited in the Carnivora and in the

Ungulata. In the Perissodactyla, the sagittal crest, ridges and extensive parietal surface are correlated with increased insertions of the temporal, while the large, strong and complicated arch has equal reference to a powerful masseter. So in the Artiodactyla, especially in the Ruminantia, the diminished surface for the temporal, and the smaller, weaker arch, both denote lessened energy in the above muscles, while the enlarged pterygoid muscular insertions show that the required action has been provided in another direction. As Prof. Cope has shown, "Forms which move the lower jaw transversely have the temporal muscles inversely as the extent of the lateral excursions of the jaw. Hence these have a diminished size in such forms as the ruminants, and are widely separated."

The singular fact that the Tylopoda alone of the selenodont Artiodactyla possess the sagittal crest, is explained by Prof. Cope, by the presence of canine teeth, which are used as weapons of offense and defense, and which demand large development of the temporal muscles.

The energy of the action of these muscles has reference to the position of the dental series. In the primitive Mammalia, as Cope shows, a considerable portion of the molar series is below and posterior to the vertical line of the orbit, and this condition has been preserved in the Rodentia and Proboscidia, forms which have the proal mastication. But in those which have lateral movements of the jaw, the molar series has gradually moved forwards. The camel alone retains the primitive condition.

The bunodont Artiodactyla, as the Dicotylidæ, have the molar series posterior to the orbit ; those with lateral movement of the jaw, the Suidæ, have them more anterior.

In the relation of the arch to the orbit, it is obvious that the position of this last must exert its influence upon the strength of the arch. When the orbit is above or below the articulation a longer and consequently a weaker arch is demanded, than when it is on a level with it. The same may be said when the orbit occupies an anterior rather than a posterior position upon the cranium. A comparison of the crania of the Tapiridæ with those of the Suidæ will corroborate this fact.

Then again the union of the bones by suture imparts a degree of elasticity to the arch which must serve to disperse over a given space the effects of shocks and blows, which might under other circumstances prove injurious.

We have already noted the peculiar vertical curvature of the arch downwards in the Rodentia. This is a decided manifestation of weakness, and is compensated in some of the families by the unusual arrangement made in the distribution of the muscular insertions of the masseter through the infraorbital opening, by which increased energy is imparted to the powers of mastication, and whereby the action of the mandible is rendered equal to the demand upon its efforts.

Where this does not exist, it is evident that the strength of the arch is still sufficient for the antero-posterior movement of the articulation so peculiar to the Rodentia and so characteristic of the act of gnawing. The ascending ramus of the mandible differs according to the food. Elevated in the Leporidæ, it is short in the Sciuridæ, and still shorter in the Muridæ. In the first, the coronoid projects but slightly, is near the condyle and far distant from the molar series, while the angle is broad and well rounded.

In the other two families, the coronoid is feeble, pointed and placed at equal distances between the condyle and the last molar ; thus the masseter does not possess a leverage as advantageous as in the Leporidæ. This muscle, however, in the rats has its maxillary attachments much developed, while few fibres spring from the arch.

It has been implied that modifications of the arch are due to variation as brought about by the effects of increased Use and Disuse. aided by the influences commonly attributed to Natural Selection. To what extent these laws have been carried since the earliest records of mammalian life, it would be useless to inquire, as palæontology affords us little or no evidence. They certainly cannot have escaped those which govern Heredity. In the Carnivora, for example, the arch remains essentially the same as it did in the days of the Creodonta, the ancestors of the cats ; and similar conditions undoubtedly apply to other groups, so far as our scanty knowledge extends. We must await farther developments for the solution of this as well as of other even more important problems.

A Matter of Priority.

By Patterson DuBois.

(*Read before the American Philosophical Society, April 5, 1895.*)

It is reported that at a meeting of the Royal Society held June 13, 1894, Mr. J. W. Swan presented a number of specimens of leaves of gold of extreme thinness which had been prepared by the process of electrodeposition. Mr. Swan's idea appears to have been to produce gold leaf by electro-chemical instead of mechanical means. The process is briefly described as follows :

"The leaves were prepared by depositing a thin film of gold on a highly polished and extremely thin electro-copper deposit. The copper was then dissolved by perchloride of iron, leaving the gold in a very attenuated condition. The leaves were approximately four-millionths of an inch thick, and some of them mounted on glass showed the transparency of gold very perfectly when a lighted lamp was looked at through them."

Within a few weeks past I, myself, observed an item going the rounds of the public press in reference to this so-called Swan process. We have